TECHNICAL REPORT ABOUT THE CONCEPT AS A RESULT OF A RISK ANALYSIS ACCORDING TO EN 1127-1:2007

Subject of this technical report:

Pneumatic Scotch Yoke Actuator
of type series RG

Manufacturer:

Flowserve Flow Control GmbH
Rudolf-Plank-Strasse 2
D-76275 Ettlingen

Report-No.: FE74751T
Revision 1.0 from 2009-08-19

Testing Body according to Directive 94/9/EC:

TÜV SÜD Automotive GmbH
Elektronik Sicherheit
Ridlerstraße 57
D-80339 Munich

Certification Body:

TÜV SÜD Product Service GmbH
Ridlerstraße 65
D-80339 Munich

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Technical report
about the concept as a result of a risk analysis according to EN 1127-1:2007

Content — Page

TÜV SÜD Automotive GmbH
Electronics Safety
Ridlerstraße 57
80339 München
Phone: (089) 5791-1393; Fax: -4438

1 Revision history

Rev.	Changes	Date	Editor
1.0	Compilation of the test report on the basis of the German test report No. FE74501T Rev. 1.0	2009-08-19	T. Moll

2 Subject of the risk analysis

The present technical report describes the execution and the particular results of the risk analysis according to EN 1127-1:2007 of the pneumatic Scotch Yoke Actuators type series RG. The risk analysis was accomplished by TÜV SÜD Automotive GmbH and assisted by the manufacturer Flowserve Flow Control GmbH.

The results of the risk analysis are summarized and evaluated in this technical report.

The issue of the German technical report was ordered at 17th June 2009 by Mr. Uwe Heisswolf from Flowserve Flow Control GmbH. At the 27th July Mr. Uwe Heisswolf ordered this English version of the technical report.

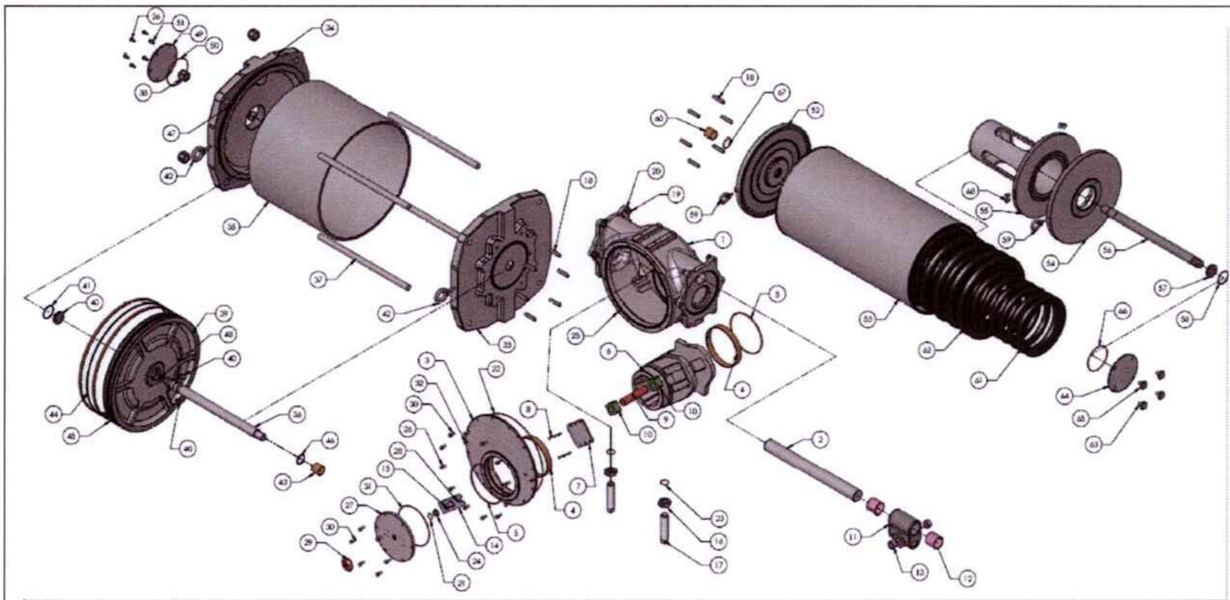
3 Introduction

The content of the risk analysis are the estimation of risks caused by explosions and the avoidance of them. Chapter 4 of this report describes the internal construction and the functionality of the apparatus. Section 5 of the report contains the underlying norms and regulations. The recognition of hazards and the risk evaluation can be found in section 6. Chapter 7 describes methods to minimize or prevent the risk of an explosion and in chapter 8 information about requirements and realizations of preventing ignition sources can be found. In section 9 procedures in order to minimize the effect of an explosion are mentioned. Chapter 10 contains information about measurement and control systems for explosion prevention and protection. In chapter 11 the intended operating conditions of the apparatus is defined and chapter 12 summarizes the primal results of the risk analysis.

This technical report is on the basis of the supplied specifications and information of the company Flowserve Flow Control GmbH.

4 Assembly and functionality of the pneumatic Scotch Yoke Actuator

The pneumatic Scotch Yoke Actuator operates with a filtrated air at a control pressure range of $3\ \text{bar} \leq P_{st} \leq 7\ \text{bar}$ and a operating temperature range of $-30°C \leq T_b \leq +80°C$. Due to the filtrated air which produces an overpressure, a piston is actuated. By a piston rod and a brace, the force is transferred to the shaft from where an apparatus can be powered. The reset force results from two ways. One cause is the return spring of the apparatus. An additional part of the reset force occurs because of the mechanical construction. The pressure compensation on the side of the piston where previously overpressure was present, and the increasing pressure on the other side, causes a resetting of the piston.



ITEM NO.	SHORTDESC	MATERIAL	QTY.	ITEM NO.	SHORTDESC	MATERIAL	QTY.	ITEM NO.	SHORTDESC	MATERIAL	QTY.	ITEM NO.	SHORTDESC	MATERIAL	QTY.
1	CENTER BODY	DUCTILE IRON	1	18	STUD	STEEL	12	35	CYLINDER	CARBON STEEL	1	52	ADAPTOR	CARBON STEEL	1
2	GUIDE ROD	ALLOY STEEL	1	19	NUT	STEEL	12	36	PISTON ROD	ALLOY STEEL	1	53	PIPE	CARBON STEEL	1
3	COVER	DUCTILE IRON	1	20	WASHER	STEEL	12	37	TIE ROD	ALLOY STEEL	4	54	END CAP	CARBON STEEL	1
4	BUSH	PTFE BRONZE	2	21	O-RING	BUNA - N	1	38	LOCKNUT	STEEL	4	55	SPRING GUIDE	DUCTILE IRON	1
5	O-RING	BUNA - N	2	22	O RING	BUNA - N	1	39	PISTON	DUCTILE IRON	1	56	PULL ROD	ALLOY STEEL	1
6	YOKE	DUCTILE IRON	1	23	O-RING	BUNA - N	2	40	SPLIT COLLAR	STEEL	4	57	SPLIT COLLAR	STEEL	2
7	RETAINER	PLASTIC	2	24	BUSH	PTFE BRONZE	1	41	RET RING	STEEL	1	58	RET RING	STEEL	1
8	SCREW	STEEL	12	25	PIN	ALLOY STEEL	2	42	BOLT	STEEL	2	59	BOLT	STEEL	2
9	PIN	ALLOY STEEL	1	26	WASHER	STEEL	18	43	BUSH	PTFE BRONZE	1	60	BUSH	PTFE BRONZE	1
10	SLIDER BLK	AL BRONZE	2	27	COVER	CARBON STEEL	1	44	QUADSEAL	RUBBER	1	61	SPRING	ALLOY STEEL	1
11	GUIDE BLOCK	DUCTILE IRON	1	28	SCREW	STEEL	1	45	WEAR RING	C FILLED PTFE	2	62	SPRING	ALLOY STEEL	1
12	BUSH	PTFE BRONZE	2	29	INDICATOR	PLASTIC	1	46	QUAD SEAL	RUBBER	1	63	BOLT	STEEL	4
13	BUSH	PTFE BRONZE	2	30	BOLT	STEEL	18	47	O-RING	BUNA - N	2	64	COVER	CARBON STEEL	1
14	PLATE	STAINLESS STEEL	1	31	O-RING	BUNA - N	1	48	O-RING	BUNA - N	1	65	WASHER	STEEL	4
15	SHAFT	STAINLESS STEEL	1	32	SCREW	ALLOY STEEL	2	49	COVER PLATE	CARBON STEEL	1	66	O-RING	BUNA - N	1
16	NUT	STEEL	2	33	ADAPTOR	DUCTILE IRON	1	50	O-RING	BUNA - N	1	67	O-RING	BUNA - N	1
17	STOP BOLT	STEEL	2	34	END CAP	DUCTILE IRON	1	51	BOLT	STEEL	6	68	BUTTON	PLASTIC	6

Picture 1: Exploded assembly drawing of the type series RG

5 European directives and normative basis of the risk analysis

The risk analysis was performed in accordance with the following directives, laws and provisions:

5.1 European directives, laws and provisions

94/9/EC[1]	European directive for explosion protection (ATEX 95)

Supplementing and detailing the requirements as well as the "Essential health and Safety Requirements" provided in EU-Directives, testing was performed according to the following additional standards and technical regulations.

1 *TÜV SÜD is Notified Body in accordance to Council Directive 94/9/EC for Equipment and protective systems intended for use in potentially explosive atmospheres with the identification number 0123*

6 Risk assessment without consideration of existing safety precautions

6.1 Determining the likelihood of an occurrence of an explosive atmosphere

The occurrence of explosive atmosphere as a result of a chemical reaction as well as pyrolysis or because of chemical processes can be excluded. In operating mode without any malfunctions, an explosive atmosphere may only occur due to external supplied gases or dusts.

6.2 Hot surfaces

If an explosive atmosphere comes into contact with a heated surface ignition can occur. Not only can a hot surface itself act as an ignition source, but a dust layer or a combustible solid in contact with a hot surface and ignited by the hot surface can also act as an ignition source for an explosive atmosphere. The capability of a heated surface to cause ignition depends on the type and concentration of the particular substance in the mixture with air. This capability becomes greater with increasing temperature and increasing surface area.

Hot surfaces in operating mode may appear at the gearbox. Furthermore, in operating mode and in case of estimated malfunctions, the possibility exists, that hot surfaces occur at the pneumatic motor, the installed pneumatic cylinder, the ball bearings for the rotary force, the ball tracks of the linkage and at the slide bearings.

6.3 Mechanical produced sparks

As a result of friction, impact or abrasion processes such as grinding, particles can become separated from solid materials and become hot owing to the energy used in the separation process. If these particles consist of oxidizable substances, for example iron or steel, they can undergo an oxidation process, thus reaching even higher temperatures. These particles (sparks) can ignite combustible gases and vapours and certain dust/air-mixtures (especially metal dust/air mixtures). In deposited dust, smouldering can be caused by the sparks, and this can be a source of ignition for an explosive atmosphere. The ingress of foreign materials to equipment, protective systems, and components, e.g. stones or tramp metals, as a cause of sparking shall be considered. Rubbing friction, even between similar ferrous metals and between certain ceramics, can generate hot spots and sparks similar to grinding sparks. These can cause ignition of explosive atmospheres. Impacts involving rust and light metals (e.g. aluminium and magnesium) and their alloys can initiate a thermite reaction which can cause ignition of explosive atmospheres. The light metals titanium and zirconium can also form incendive sparks under impact or friction against any sufficiently hard material, even in the absence of rust.

The occurrence of mechanical sparks can be excluded in operating mode and in case of a malfunction. In the situation of a rare malfunction, sparks may produced due to a mechanical impact by a spring fracture.

6.4 Electrical apparatus

In the case of electrical apparatus, electric sparks and hot surfaces can occur as sources of ignition. Electric sparks can be generated, e.g. when electric circuits are opened and closed, by loose connections and by stray currents.

The considered apparatus contains no electrical components.

6.5 Stray electric currents

If lightning strikes in an explosive atmosphere, ignition will always occur. Moreover, there is also a possibility of ignition due to the high temperature reached by lightning conductors. Large currents flow from where the lightning strikes and these currents can produce sparks in the vicinity of the point of impact. Even in the absence of lightning strikes, thunderstorms can cause high induced voltages in equipment, protective systems, and components.

Due to the facts that the pneumatic actuator consists only of metal parts which are conductively connected and the apparatus has to be earthed according to the regulations, no hazard can appear caused by stray currents
The operator has to verify that no stray currents (e.g. because of a lightning strikes) can occur.

6.6 Static electricity

Incendive discharges of static electricity can occur under certain conditions. The discharge of charged, insulated conductive parts can easily lead to incendive sparks. With charged parts made of non-conductive materials, and these include most plastics as well as some other materials, brush discharges and, in special cases, during fast separation processes (e.g. films moving over rollers, drive belts), or by combination of conductive and non-conductive materials) propagating brush discharges are also possible. Cone discharges from bulk material and cloud discharged can also occur.
Brush discharges can ignite almost all explosive gas and vapour atmospheres. According to the present state of knowledge, the ignition of explosive dust/air atmospheres with extremely low minimum ignition energy by brush discharges cannot be excluded. Sparks, propagating brush discharges, cone discharges and cloud discharges can ignite all types of explosive atmospheres, depending on their discharge energy.

All metallic parts of the pneumatic actuator are conductively connected. There exists no plastic surfaces from which a hazard due to static electricity can occur.

6.7 Electromagnetic waves

Electromagnetic waves are emitted by all systems that generate and use radio frequency electrical energy (radio-frequency systems), e.g. radio transmitter or industrial or medical RF generators for heating, drying, hardening, welding, cutting, etc.

A hazard due to electromagnetic waves is not expected but has to be estimated and avoided by the operator of the system.

6.8 Ionizing radiation

Ionizing radiation generated, for example, by X-ray tubes, and radioactive substances can ignite explosive atmospheres (especially explosive atmospheres with dust particles) as a result of energy absorption. Moreover, the radioactive source itself can heat up owing to internal absorption of radiation energy to such an extent that the minimum ignition temperature of the surrounding explosive atmosphere is exceeded.

A hazard by ionizing radiation can be excluded.

6.9 Ultrasonics

In the use of ultrasonic sound waves, a large proportion of the energy emitted by the electroacoustic transducer is absorbed by solid or liquid substances. As a result, the substance exposed to ultrasonics warms up so that, in extreme cases, ignition may be induced.

A hazard by ultrasonics can be excluded.

6.10 Adiabatic compression

In the case of adiabatic or nearly adiabatic compression and in shock waves, such high temperatures can occur that explosive atmospheres (and deposited dust) can be ignited. The temperature increase depends mainly on the pressure ratio, not on the pressure difference. Shock waves are generated, for example, during the sudden relief of high-pressure gases into pipelines. In this process the shock waves are propagated into regions of lower pressure faster than the speed of sound. When they are diffracted or reflected by pipe bends, constrictions, connection flanges, closed valves etc., very high temperatures can occur. This is always happens when gases are going very fast compressed without losing thermal energy. Following rule applies: The more the output pressure is, the higher becomes the temperature.

At the considered apparatus is no adiabatic compression expected.

6.11 Estimating the possible effects of an explosion

In the event of an explosion, the possible effects are flames, heat radiation as well as pressure waves and flying debris. The consequences of the above are related to the chemical and physical properties of the flammable substances, the quantity and confinement of the explosive atmosphere, the geometry of the surroundings as well as the physical properties of the endangered objects.

7 Risk assessment with consideration of existing safety precautions

7.1 Constructive explosion protection

Because of the operating procure the avoidance of explosive atmosphere is not possible.

7.2 Dilution by ventilation and avoiding dust accumulations

A dilution by ventilation or an exhaust system is not planed and there are no special procedures of avoiding dust accumulations intended.

7.3 Classification of hazardous places

A classification of hazardous places is not present.

7.4 Hot surfaces

By using a hot service medium, a hazard because of hot surfaces is possible. Additionally, a heating of the operating shaft, occurred by friction, has to be considered.

7.5 Mechanical produced sparks

The occurrence of mechanical sparks can be excluded in operating mode and in case of a malfunction. In the situation of a rare malfunction, sparks may produced due to a mechanical impact by a spring fracture.

7.6 Electrical Systems

Not applicable.

7.7 Static electricity

All metallic parts of the pneumatic actuator are conductively connected and the complete system is earthed. Because of that reason, no hazard occurs by static electricity.

7.8 Electromagnetic waves

Not applicable.

7.9 Ionizing radiation

Not applicable.

7.10 Ultrasonics

Not applicable.

7.11 Exothermic reactions, including self-ignition of dusts

Not applicable.

8 Requirements for the design and construction of equipment, protective systems, and components by avoidance effective ignition sources

8.1 General information

Due to the application, it is not possible to remove effective ignition sources from the hazardous area.

8.2 Hot surfaces

A hazardous situation in operating mode, in case of a malfunction or in case of a rare malfunction can be excluded. In order to prevent heating by friction, the maximum rotary speed of the apparatus has to be $V_{max} < 1m/s$ and the maximum number of switching cycles should not exceed five per minute. It is not allowed to go into service with hot pressure air.

8.3 Mechanical produces sparks

Mechanically produced sparks due to a spring fracture is highly improbable. All springs have been well designed for the estimated forces. Additionally, the enclosure of the springs is hermetically sealed so that no spring will get in contact with explosive mixtures.

8.4 Electrical systems

A hazard by near electrical systems cannot be excluded. Appropriate measures are in the responsibility of the operator.

8.5 Static electricity

It is no hazard because of static electricity present. All metallic parts of the pneumatic actuator are conductively connected and the complete system is earthed.

8.6 Electromagnetic waves

It is no hazard because of electromagnetic waves present.

8.7 Ionizing radiation

It is no hazard caused by ionizing radiation present.

8.8 Ultrasonics

It is no hazard caused by ultrasonic waves present.

8.9 Adiabatic compression

It is no hazard because of adiabatic compression present.

8.10 Exothermic reactions, including self-ignition of dusts

A hazard situation because of exotermic reactions, including self ignition of dusts, can be excluded.

9 Requirements for the design and construction of equipment, protective systems, and components by avoidance of effective ignition sources

9.1 Explosion-resistant design

The apparatus was not explosion-resistant designed, and explosion suppression does not apply. There are no devices inside the apparatus to prevent explosion propagation, and no deflagration arresters or extinguishing barriers are installed. Furthermore, no emergency measures, e.g. an emergency shutdown, are intended.

10 Principles of measuring and control systems for explosion prevention and protection

There are no measuring or control systems for the avoidance of explosive atmosphere or for the avoidance of effective ignition sources intended.

10.1 Information for use

The handbook contains information about the maintenance of the apparatus.

10.2 Information for commissioning, maintenance and repair to prevent explosion

The handbook contains information about the installation and maintenance of the apparatus. Special hints with regard to explosion protection are not included.

10.3 Qualifications and training

The commissioning and installation of the apparatus have to be done by qualified and well trained staff. The information about the intended operating conditions must be considered.

11 Intended operating conditions

It must be guaranteed, that all metallic parts are permanently and conductively connected and the apparatus has to be earthed. The maximum rotary speed of the apparatus has to be V_{max} < 1m/s and the maximum number of switching cycles should not exceed five per minute. It is not allowed to go into service with hot pressure air.

12 Test result

If the apparatus operates as directed according to chapter 11, no ignition sources are present. Due to that fact, the Directive 94/9/EC does not apply and therefore no special marking has to be placed.

Thomas Moll
Electronics Safety
Laboratory of explosion protection
Project Manager

Jürgen Blum
Electronics Safety
Laboratory of explosion protection
Reviewer